

Although we are unable to give, this week, a complete account of the final doings of the Conference, what was done at the last meeting is partly known, and it is clear that the Conference has been a great success, and that much solid work has been accomplished by the forty or fifty astronomers who attended one meeting or the other.

At the final general meeting Admiral Mouchez announced that all necessary arrangements had been made with the French Government to enable the Observatories of Paris, Algiers, Bordeaux, and Toulouse, to accept at once the conditions proposed by the Conference. M. Cruls, Director of the Rio Observatory, and M. Beuf, Director of the La Plata Observatory, also accepted at once the same conditions; their instruments being already ordered, and all expenses provided for. Most of the official astronomers had not as yet obtained the necessary grants of money from their respective Governments; but among those who expressed their readiness to take a share in the work, if funds can be provided, were Struve, of Pulkova; Weiss, of Vienna; Auwers, of Berlin; Christie, of Greenwich; Pujazon, of San Fernando; Oom, of Lisbon; Gill, of the Cape; and Russell, of Sydney, who answered also for Ellery, of Melbourne. Prof. Peters, speaking for the United States, said that ten of their Observatories were anxious to join in this undertaking, but he did not know whether they would accept the conditions proposed by the Conference. Omitting, therefore, these ten doubtful Observatories, we see that already four Observatories in the North and two in the South have given in their adhesion, and these will probably soon be joined by six other leading Observatories in the northern hemisphere and by three in the southern. Henceforward we need have no time or money spent on stellar photographs which will not find their place in a well-thought-out and general scheme.

The estimated cost for each Observatory, including instruments, extra assistant, plates, measurements, &c., is about £4000.

We believe that among the resolutions arrived at at the last meeting was one recommending the erection by France of an Observatory at Réunion, and by England of one in New Zealand.

The Permanent Committee appointed consists of all the Directors of the Observatories taking part in the work, with a certain number of members not necessarily actually engaged in this work. The names of the Committee are Christie, Dunér, Gill, Prosper Henry, Janssen, Lœwy, Pickering, Struve, Tacchini, Vogel, Weiss; and, as Directors of Observatories who have decided already to join, Cruls, Beuf, Mouchez, Trépied, Baillaud, and Rayet.

The Conference nominated Janssen and Common as a Committee to consider the application of photography to other celestial bodies not included in the scheme of a photographic chart.

The hospitality of the French Government and men of science to the members of the Conference can be judged from the following list of festivities provided in their honour. In addition to the welcome of the Conference by the Minister of Foreign Affairs already mentioned, Admiral Mouchez gave a *soirée* at the Observatory on Tuesday evening, April 19. The Bureau of the Conference were presented to the President of the Republic on Wednesday, the 20th. A banquet was given by the Minister of Foreign Affairs at his official residence, on Thursday, the 21st. M. Janssen invited the Conference to his Observatory at Meudon on Friday afternoon, the 22nd. On Saturday there was a ball at the Hôtel Continental and a special performance of "Hamlet" at the Comédie Française on Sunday. A banquet was given by Admiral Mouchez at the Observatory, on Sunday, to all the members of the Conference and many of the

leading French *savants*, including MM. de Lesseps, Frémy, Becquerel, Hébert, and others. On Saturday, the 23rd, the English astronomers gave a dinner to their French *confrères*; the Astronomer-Royal presided, Mrs. Christie was also present.

ON ICE AND BRINES.¹

II.

THE second part of the paper is occupied by the study of the melting of pure ice in sea-water and other saline solutions. A large number of experiments were made with solutions of concentration comparable with that of sea-water, and in one or two cases the experiments were extended to low temperatures and strong solutions. As a rule, from 50 to 100 grammes of solution, cooled to 0° C., were mixed with an equal weight of pounded ice, also at 0° C. The thermometer used for all these determinations was one of Geissler's normal ones, divided into tenths of a degree Centigrade; and its zero-point was verified almost daily. Along with the thermometer, a pipette of suitable capacity was immersed in the beaker, and used with the thermometer for keeping the mass well mixed. Its upper aperture was closed with a small cork, which was removed from time to time to permit of some of the brine being sucked up and allowed to run back again. The inside of the pipette was thus kept constantly moistened with the slowly altering solution in the beaker. The temperature was read after very thorough mixing and the sample thereupon immediately removed and preserved for analysis.

As a rule samples were taken for analysis at intervals of 0·4° C. The results for three classes of salt in dilute solutions are arranged in Tables IV., V., and VI.

TABLE IV.—Giving the percentage of chlorine in solutions of various chlorides in which ice melts at given temperatures.

Temperature of melting ice.	Chloride in solution.						
	HCl.	NaCl.	KCl.	(Sea-Water.)	MgCl ₂ .	CaCl ₂ .	BaCl ₂ .
	Per cent. chlorine in solution.						
° C.							
- 3·5	3·06	3·30	—	—	4·12	—	—
- 3·0	2·68	3·02	3·00	—	3·62	3·70	—
- 2·5	2·28	2·53	2·50	—	3·12	3·20	—
- 2·0	1·85	2·02	2·00	—	2·62	2·70	2·72
- 1·5	—	1·50	1·50	1·500	1·19	2·15	2·10
- 1·0	—	1·02	1·02	1·034	1·51	1·50	1·47
- 0·5	—	0·50	0·52	0·588	0·87	—	—

TABLE V.—Giving percentage of K in solutions of various potassium salts in which ice melts at given temperatures.

Temperature of melting ice.	Salt in Solution.			
	KCl.	KI.	$K \frac{Cl + I}{2}$	KOH.
	Per cent. K in Solution.			
° C.				
-3·0	3·29	3·02	3·15	—
-2·5	2·79	2·59	2·68	2·60
-2·0	2·28	2·13	2·17	2·08
-1·5	1·74	1·63	1·66	1·57
-1·0	1·18	1·13	1·12	—
-0·5	0·59	0·60	0·57	—

¹ Paper read before the Royal Society of Edinburgh, by J. Y. Buchanan, on March 27 last. Continued from vol. xxxv. p. 611.

TABLE VI.—Giving percentage of hydrogen in solutions of various hydrogen salts in which ice melts at given temperatures.

Temperature of melting ice.	Salt in solution.			
	H ₂ SO ₄ .	HCl.	HNO ₃ .	HKO.
	Per cent. H in solution.			
° C.				
-3°0	0'144	0'076	0'077	—
-2°5	0'119	0'065	0'065	0'066
-2°0	0'097	0'052	0'052	0'053
-1°5	0'073	—	0'042	0'041
-1°0	0'048	—	0'032	—

On considering them, it was at once evident that the lowering of the melting-point of ice followed the concentration of the solution, but the law deviated in all cases from that of strict proportionality to the amount of salt dissolved, in some cases to a greater extent than in others. In comparing the effects of different salts in solution on the melting-points of ice, no simple connexion could be traced between their absolute weights and the effects produced; but on comparing chemically equivalent weights, a very close connexion was discovered. This will be evident from the inspection of the tables. In each the first column contains the temperatures at which pure ice melts; and in the parallel columns, the percentages of chlorine, potassium, or hydrogen in the solutions of the salts indicated at the head of each column, when ice melts in them at the temperature indicated. The figures thus give numbers proportional in each table to the chemically equivalent weights of the different salts. They show at first that, whereas the presence of equal absolute weights in solution produces very different effects, the presence of chemically equivalent weights produces very similar effects. On closer inspection, it is seen that the effects are almost identical where the elements to which the common constituent is united belongs to the same group of the periodic series, and differ sharply where these elements belong to different groups. In the case of the chlorides of sodium and potassium the number expressing the percentage¹ of chlorine in the solution expresses equally the depression of the melting-point of ice in terms of the Centigrade scale. The same depression of melting temperature is produced by 10 per cent. less of chlorine united to hydrogen, and by 30 to 35 per cent. more of chlorine when united to magnesium, calcium, or barium.

The results obtained with sea-water are also given, for comparison. It will be seen that it behaves very approximately as a solution of chloride of sodium containing the same amount of chlorine.

It is perhaps not very astonishing that unit weight of potassium in saline solution should produce the same effect in lowering the melting-point of ice, whether it is united to Cl, to I, or to OH; but it shows clearly how independent this action is of the character of the body in solution when we find the effect produced by unit weight of hydrogen identical whether it is united to such opposite radicles as Cl or OK. Table VI. shows further the effect of valence. While a given weight of hydrogen produces the same effect in solution whether it be united to the very different but both univalent radicles Cl and OK, its effect is reduced by one-half when united to the bivalent SO₄. That valence is not the only factor is shown by comparing the effects of hydrogen and potassium when united to the common element, chlorine. Hydrochloric acid in solution produces a markedly more powerful lowering effect on the melting-point of ice than the equivalent amount of chloride of potassium. Of all

¹ All percentages are by weight.

the substances that I have experimented on, hydrochloric acid is the most energetic in reducing the melting-point of ice, and with ordinary strong acid and pounded ice there is no difficulty in producing temperatures as low as the freezing-point of mercury. In the case of hydrochloric acid, sulphuric acid, chloride of sodium, and chloride of calcium, I have carried my experiments to low temperatures and great concentration. But before passing to them it is well to consider the more dilute solutions with regard to their density.

That the mere density of the solution in which the ice is melting has no direct connexion with the lowering of its melting-point is shown by the following table, in which the specific gravities (at 15° C.) are given of the solutions of different salts which give the same depression of melting-point.

Temperature of melting.	Specific gravity of solutions of				
	NaCl.	KCl.	MgCl ₂ .	CaCl ₂ .	BaCl ₂ .
° C.					
-2°86	1'03370	1'03850	1'03893	1'04756	—
-1°8	1'02174	1'02535	1'02715	1'03262	1'06633

There are many similarities in the effects produced by greatly increasing the pressure upon pure water and by dissolving salts in it. First, there is an absolute diminution in the volume of the solution as compared with the sum of the volumes of its components; second, in virtue of this compression by molecular forces it has become less compressible by mechanical means; third, the temperature of maximum density and the freezing temperature are lowered; and fourth, the former of these two temperatures is lowered more rapidly than the latter. All these effects are produced *in kind* by increasing the pressure on pure water. Whether, or in how far, they agree in degree must be decided by future experiments.

Experiments with Concentrated Solutions.—Several series of experiments have been made with hydrochloric acid, chloride of sodium, and chloride of calcium, and also with sulphuric acid. Table VII. gives the results, in the same form as preceding tables, for the chlorides:—

TABLE VII.

Temperature of melting ice.	Salt dissolved.		
	HCl.	NaCl.	CaCl ₂ .
	Per cent. Cl in solution.		
° C.			
-35	15'26		
-30	13'98		15'97
-25	12'60		14'47
-20	11'00		12'65
-15	9'17	11'10	11'29
-10	7'02	8'40	8'93
-5	4'15	4'72	5'05

It will be seen that, in proportion as the solution becomes more concentrated, further additions of salt produce a greater effect in lowering the melting-point of ice, and at a temperature of -15° C. equivalent weights of NaCl + CaCl₂ produce identical results. In Table VIII. the results for hydrochloric acid and sulphuric acid are given in terms of the percentage of hydrogen in the solution.

TABLE VIII.

Temperature of melting ice.	Acid dissolved.	
	HCl.	H ₂ SO ₄
	Per cent. H in solution.	
°C.		
-25	0·355	0·538
-20	0·310	0·487
-15	0·258	0·418
-10	0·198	0·332
-5	0·117	0·205

The temperatures given in these tables are all in terms of the same thermometer, which has not been verified for this part of its scale by comparison with a standard or with the air thermometer.

It is exceedingly difficult, as a rule, to ascertain the trustworthiness of a thermometer at low temperatures. This difficulty would be removed if the temperature at which ice melts in solutions of some very soluble salts of different concentrations were carefully and accurately determined with a good air thermometer. If, for instance, this were done for chloride of calcium solution, which in many ways would be a particularly convenient one, there would be no difficulty in verifying a thermometer at any moment at temperatures as low as -30° C. by mixing pounded ice with the strong solution, immersing the thermometer in it, taking a series of readings of the instrument, while a series of samples of the liquid is taken and in them the chlorine determined. There are considerable advantages in this method of verification of thermometers by chemical means, especially as it obviates the use of the air thermometer, which is always inconvenient. The experiments of Pfaundler and Schnegg on the freezing of aqueous solutions of sulphuric acid can be used for this purpose. But it would be better to have a series of observations made for the purpose with the more convenient chloride of calcium solution.

Freezing Mixtures.—The results obtained in examining the melting-point of ice in saline solutions affords data for mixing freezing baths of any degree of cooling power. With chloride of sodium, for instance, a rough rule is to have such an amount of salt dissolved in the brine that the percentage of chlorine shall give the desired temperature in Centigrade degrees below the freezing-point. In my experiments in freezing sea-water in quantities of 300 grammes, I usually made up the bath of 500 grammes pounded ice, 400 grammes water, and 45 grammes common salt. When mixed, the liquid contained about 4 per cent. Cl, and gave a temperature a little below -4° C. In the course of an hour the liquid would contain 3 per cent. to 3·25 per cent. Cl, and the temperature have risen to -3° C. By using such baths freezing operations can always be kept completely in hand.

Summary.—Owing to its peculiar physical properties it is impossible to prepare the crystalline solid which separates from sea-water and analogous saline solutions in a condition to enable the question, whether the salt does or does not form part of the solid matter of the crystals, to be solved directly by chemical analysis.

So far as chemical analysis is applicable, it is in favour of the salt belonging exclusively to the adhering brine. When sea-water is carefully frozen artificially, the ratio between the chlorine and the sulphuric acid is the same for the solid contents of the original water, the crystals, and the mother-liquor. It is exceedingly unlikely if part of the salt went into the crystals, leaving the remainder in the

brine, that there would be no selective separation of its constituents.

It has been shown (and the whole of the second part of the paper is taken up with this subject) that snow or pure lake ice, which, when melting by itself or immersed in pure water at atmospheric pressure, melts at the constant temperature called 0° C. or 32° Fahr., changes its melting temperature when immersed in a saline solution. The altered melting temperature, however, is the same for solutions of the same composition (no doubt with some allowance for pressure) and different for solutions of different composition.

The temperature at which pure ice melts in a solution is identical with that at which ice separates from the same solution on being sufficiently cooled.

When sea-water is frozen to the extent of 15 per cent. of its mass, and the crystals so formed are allowed to melt in the liquid in which they have been produced, they melt exactly as they have been formed. If snow or pure ice be immersed in the brine formed by partially freezing sea-water, it melts at the same temperature as the ice which had been formed by freezing the sea-water, so long as the chemical composition is the same in each case.

When saline solutions are cooled for a sufficient length of time at a sufficiently low temperature, there arrives a certain concentration at a certain temperature, when further removal of heat causes solidification of the brine as a whole (cryohydrate).

The concentration necessary for the solidification of even the cryohydrate of highest melting temperature is such that in the *primary* freezing of sea-water in nature no such body can be formed. It would follow from this consideration alone that the first ice formed on the sea in Arctic regions consists of pure ice, and it is also certain that it would retain a large quantity of the residual sea-water in its interstices. During the winter this inclosed liquor would solidify in the interstices of the crystals to ice and cryohydrates, in so far as the temperature and the nature of the salts in solution would permit. From my experiments with chloride of calcium, and the existence of brines observed to remain liquid at -30° C. at the winter-quarters of the *Vega*, it is unlikely that sea-water, as a whole, can ever be completely solidified in nature. The presence of unfreezable or difficultly freezable brine in freshly-formed sea-water ice explains its eminently plastic character even at very low temperatures. The presence of similar unfrozen brine in natural land ice at temperatures neighbouring to 0° C. explains its slightly plastic character, which is sufficient to account for the slow fluid motion of glaciers under the long-continued pressure of their own weight.

The fact that cryohydrates of different salts solidify and melt at different temperatures, sufficiently explains the various composition of different specimens of *old* sea ice.

The physical phenomena observed in freezing sea-water and saline solutions of moderate concentration, are all easily and simply explained on the hypothesis that the crystalline body formed is pure ice. Thus, the heat removed in freezing sea-water to the extent of 15 per cent. of its mass accounted for the production of the same amount of ice as was given by calculation on the basis of the chlorine found in the mother-liquor.

The apparent expansion, near the melting-point, of ice formed by the freezing water which contains any salt at all is perfectly explained on the hypothesis that in the act of freezing the water rigidly excludes all saline matter from participation in its solidification.

The same applies to the latent heat of water containing salt in matter. Pettersson made two determinations of the latent heat of sea-water containing 1·927 per cent. Cl and 3·53 per cent. salt. The freezing took place in the one case between the temperatures $-9^{\circ}0$ and $-7^{\circ}47$ C., and in the other between $-8^{\circ}35$ and $-6^{\circ}94$ C., and the

results he found were 52.7 and 51.5. The mean initial temperature in these two experiments is $-8^{\circ}7$ C., and the mean final temperature $-7^{\circ}2$ C. At $-7^{\circ}2$ C., ice would form on cooling, and would melt on warming a solution of chloride of sodium containing 6.48 per cent. Cl, which represents 11.87 per cent. of the sea salt. In order to concentrate a brine containing 3.53 per cent. salt to one containing 11.87 per cent., 70 per cent. of the water in it must be removed. Hence in sea-water freezing at a final temperature of $-7^{\circ}2$ C., there is formed 70 per cent. of ice, and there remains liquid 30 per cent. of brine. Freezing began at the mean temperature $-8^{\circ}7$ C., and the latent heat of pure ice at this temperature is 75. Calculating the latent heat of this mixture from the heat liberated in the calorimeter during freezing, and assuming that the whole mass had solidified, Pettersson's results give the mean latent heat of this sea-water as 52.1. Calculating the apparent latent heat on the assumption that 70 per cent. of the mass solidifies into pure ice and that 30 per cent. remains liquid, we get the number 51.5. On all grounds therefore we must conclude that pure ice is the primary product in freezing sea-water and saline solutions of moderate concentration.

The fact that ice melts in sea-water at a temperature of $-1^{\circ}6$ C. to $-1^{\circ}8$ C., according to its saltiness, explains the anomalous distribution of temperature in Antarctic waters, and furnishes an account of the motive power which draws the surface water of cold temperate regions into the deeper layers, and after dilution with the melted matter of the icebergs, to the surface layers of Antarctic latitudes. Forming as it does an important factor of oceanic circulation, this part of the subject was treated in a separate paper, of which an account has already been given in NATURE (vol. xxxv. p. 516).

THE CLASSIFICATION OF SPIDERS.¹

ALTHOUGH Dr. Thorell's paper is nominally only a criticism of Dr. Bertkau's views, it is really a masterly sketch of the literature on the subject of the classification of spiders, and a review of the methods of various authors from Lister downwards. The two leading views at present held on this subject appear to be represented by the author (Dr. Thorell) and Dr. Bertkau. These two views may be stated generally as *anatomical* v. *biological*, the former being the basis of Dr. Bertkau's classification, the latter (combined with considerations of external structure) that of Dr. Thorell. Dr. Thorell successfully, as it appears to us, defends the classification provisionally adopted in 1869, in his work "On European Spiders," from the sweeping charge that it is neither natural nor equal, nor based on characters of sufficient importance and distinctly expressed, though at the same time he freely admits its inevitable imperfection. He shows that in no branch of Nature are the subordinate groups of exactly equal value, nor should it be expected that the same equal systematic value would be found in the subordinate groups of the class Arachnida. It is well to remember that zoologists have to form their groups out of such materials as have come to their hands ready provided for them by Nature. They cannot expect to advance natural science by constructing out of limited materials a perfectly symmetrical system, and then insisting that all the diverse forms of Nature shall, *nolens volens*, be stuffed somewhere or other into it. Equality, therefore, of systematic value in the various groups into which spiders (Araneidea) may be divided can at best be only approxi-

mate; and it seems evident that as our knowledge of structure, whether external or internal, or of habits as dependent on and arising out of structure, becomes more extensive and exact, so some further modifications may become necessary in the primary divisions of spiders. After subjecting Dr. Bertkau's classification (which is based principally on the breathing-organs) to a minute and destructive criticism, Dr. Thorell modifies his former views by reverting, in some measure, to the Latreillian division of spiders into (1) those possessing four air-sacs, *Tetrapneumones*; (2) those with two, *Dipneumones*; still, however, retaining the old Latreillian biological divisions, *Territelariae*, *Tubitelariae*, *Orbitelariae*, &c., based on habits, because the groups so divided may yet be thoroughly and scientifically differentiated by important and trustworthy structural characters. These divisions (now called by Dr. Thorell "tribus") are, as is well known, seven in number, and each is subdivided into families, which, with few exceptions, include only European species, Dr. Thorell's opportunities for the study of exotic groups not enabling him to construct a more complete subdivision of all known spiders. Dr. Bertkau's primary division of the Araneidea is into two groups, called suborders—*Tetrasticta*, with four breathing-apertures, and *Tristicta*, with three. Dr. Thorell shows conclusively that in the present state of our knowledge of the respiratory system of spiders (though this is far advanced beyond what it was in Latreille's days, and in a great degree the advancement is admitted to be due to Dr. Bertkau's labours) these two suborders are artificial rather than natural; as are also his subdivisions of the *Tristicta*, which are based on the undoubtedly remarkable characters to which such great prominence was given by the late Mr. Blackwall, that is, the possession or absence of a *cribellum* and *calamistrum*, the use of these in primary subdivision bringing together spiders not closely allied by any other natural characters. Dr. Thorell attributes a certain amount of classificatory importance to these organs by his intercalation of the families of his largest "tribus" possessing them, in a kind of osculant or collateral way, and of the other "tribus" in which they are found, in a linear arrangement, guided, however, in both cases by their possessing such other characters as, in all instances, fully warrant the position assigned to them. The anatomical study of the *tracheae* (properly so called) of spiders seems to be yet in its infancy. Certainly at present these organs of respiration do not appear to warrant the importance attributed to them by Dr. Bertkau; and although Dr. Thorell's primary subdivisions are, in their *names*, strictly speaking, based on only biological characters, yet in reality they severally enshroud the most important structural ones, and hold all known spiders in a fairly natural system. They are, moreover, well known, and appear likely to be adopted for some time yet to come, with more or less modification, by the majority of araneologists.

O. P. CAMBRIDGE.

CHRISTMAS ISLAND.

THE following account of the little-known Christmas Island, situated in the Indian Ocean, south of Java, may be of interest. Capt. Maclear and his officers collected a variety of specimens, which have been forwarded to the Museum of Natural History and to the Royal Gardens, Kew, but they do not seem to have succeeded in making their way through the dense jungle to the upper part of the island, to ascertain the geological character of the mountain originally protruded from the depths. It is a little remarkable that, in a sea so calculated to encourage coral growth, no new reefs should have formed round the island since the ancient ones were elevated above the surface. The Cocos or Keeling

¹ "On Dr. Bertkau's Classification of the Order Araneae, or Spiders," by Dr. T. Thorell (*Ann. and Mag. N.H.*, April 1886, pp. 301-26). (See especially the following works by Dr. Bertkau:—"Versuch einer natürlichen Anordnung der Spinnen," *Archiv. für Naturgeschichte*, xlv. 1, pp. 351 et seq., 1878; and "Ueber das Cribellum und Calamistrum; ein Beitrag zur Histologie, Biologie, und Systematik der Spinnen," *ibid.*, xlviii. 1, pp. 316 et seq., 1882.)